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14. ABSTRACT

This Instrumentation Profile is intended to provide a starting point for interoperability of Fibre Channel end-items in a test-vehicle instrumentation environment. It is envisioned this profile will be one of a family of interoperability documents. When taken as a whole, interoperability between compliant nodes will be assured. Since this document is focused at the system level, the target audience is both the end-item designer concerned about interoperability and the instrumentation engineer concerned with understanding the capabilities and tradeoffs of such a system.

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Fibre Channel
Instrumentation Environment Profile (IEP)

Version 0.8

20000407 133

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Foreward (This foreward is not part of the Profile)

This profile defines functional requirements for an interoperable Fibre Channel based instrumentation communications bus.

This profile was prepared by the NexGenBus project team. The project was started in 1997.

Requests for interpretation, suggestions for improvements or addenda, or defect reports are welcome. They should be sent to the NexGenBus project office, 47758 Ranch Road, Bldg 1492, Unit 1, Patuxent River, MD 20670-1456 or JonesSR@Navair.Navy.Mil. Additional information may be found at http://nexgenbus.nawcad.navy.mil.

The initial draft will be released for general comment with a presentation made at ITC/USA '99 in Las Vegas, October 26-28. Comments from the initial draft will be incorporated and submitted to the Range Commanders Council (RCC) Telemetry Group. The RCC will initiate the formal Pink Sheet process where comments will be solicited before becoming an official RCC standard.

The members of the NexGenBus team at the time of this draft are:

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1 Introduction

1.1 Purpose

This Instrumentation Profile is intended to provide a starting point for interoperability of Fibre Channel end-items in a test-vehicle instrumentation environment. It is envisioned this profile will be one of a family of interoperability documents. When taken as a whole, interoperability between compliant nodes will be assured. Since this document is focused at the system level, the target audience is both the end-item designer concerned about interoperability and the instrumentation engineer concerned with understanding the capabilities and tradeoffs of such a system.

1.2 Scope

This document specifies a minimum required to achieve interoperability between multiple vendors' end-items on a Fibre Channel instrumentation bus. This document only addresses the ability to move the data. The format of the data is beyond the scope of this document.

1.3 Document Structure

Section 1 provides top level information to help the reader understand how to get the most from this document.
Section 2 lists other references important for a complete understanding
Section 3 explains new terms and abbreviations
Section 4 addresses interoperability issues that may affect an instrumentation system network.
Section 5 is normative and addresses the issues defined in section four against the relative standards where interoperability would be impacted.
Section 6 is informative and covers many issues that may make the system more usable, capable, or fault tolerant, but are not specifically required for interoperability.

1.4 Precedence

The order of precedence for instrumentation interoperability shall be this document, the FC-AE profile (when published), and the Fibre Channel suite of standards.

1.5 Responsibility

This document is a result of a joint effort between the Office of the Secretary of Defense (OSD) Central Test & Evaluation Program (CTEIP) Office and the Range Commanders Council (RCC) Telemetry Group. Cognizance of this profile remains with the RCC Telemetry Group.

The Fibre Channel documents referenced throughout this profile are the responsibility of the T11 Technical Committee (TC) under Accredited Standards Committee (ASC) NCITS (National Committee for Information Technology Standardization). In turn, NCITS operates under the procedures of the American National Standards Institute (ANSI).

1.6 Approach

Interoperability and system requirements defined early in the Next Generation Instrumentation Bus Project were used as a baseline. The system requirements were identified as either interface or application requirements. The interface requirements are necessary for two nodes within a network to exchange data. Interface requirements are considered normative and are the basis for sections 4 and 5. Application requirements are necessary for an instrumentation network to perform in a test vehicle environment, but may not be needed for interoperability. Application requirements may be normative and included in section 5 or they may be informative and added to section 6.

The Fibre Channel Avionics Environment (FC-AE) sub-committee of Technical Committee T11 is working on a similar document for production avionics use. The required/desired deviations to the Fibre Channel Standards for avionics applications are worked through T11 by the FC-AE. Requirements for avionics applications are practically the same as for instrumentation applications. The major issues the instrumentation community may raise with Fibre Channel are expected to be resolved by the FC-AE due to the similarities. In the case where the instrumentation environment may have a greater need, the issue will be worked through the FC-AE or other T11 committees as appropriate.

2 References

2.1 Standards

ANSI X3.230-1994	Information Technology – Fibre Channel Physical and Signaling Interface (FC-PH), 1994
ANSI X3.297-1997	Information Technology – Fibre Channel Physical and Signaling Interface - 2 (FC-PH-2), 1997
ANSI X3.303-1998	Information Technology – Fibre Channel Physical and Signaling Interface - 3 (FC-PH-3), 1998
ANSI X3.272-1996	Information Technology – Fibre Channel Arbitrated Loop (FC-AL), 1996
ANSI X3.nnn-1999	Fibre Channel Avionics Environment Technical Report (due 12/99)
[ANSI X3.nnn-yyyy	*FC-IP?]*
[RFC 791	*DARPA Internet Program Protocol Specification, September, 1981]*

3 Abbreviations, Definitions, & Conventions

Arbitrated Loop – A Fibre Channel topology where nodes are linked together in a closed loop. Traffic is managed with a token-acquisition protocol, and only one connection can be maintained in the loop at a time.

Class 1 – Dedicated connection allocating full bandwidth between a pair of ports. Class 1 provides confirmation of delivery or notification of non-delivery between the source and destination ports.

Class 2 – Connectionless class of service with confirmation of delivery or notification of non-deliverability of frames. No bandwidth is allocated or guaranteed.

Class 3 – Connectionless class of service providing a datagram-like delivery service with no confirmation of delivery, or notification of non-delivery.

Class 4 – Connection oriented class of service which provides a virtual circuit between a pair of ports with guaranteed bandwidth and latency with confirmation of delivery and notification of non-delivery.

Class 6 – A derivative of class 1 that provides a reliable one to many multicast service with confirmation of delivery and notification of non-delivery.

classes of service

command-response architecture – A network which contains a device which controls the access of the other nodes to the network.

counter-rotating ring – An arrangement whereby two signal paths, the directions of which are opposite, exist in a physical ring or loop topology.

F_Port – Fabric Port. A Fibre Channel term, referring to the port residing on the Fabric (Switch) side of the link. It attaches to a N_Port (Node Port) at the connected device, across a link.

fabric – denotes the interconnect of ports without regard to topology

Fabric – The Fabric is a transport medium that provides switched interconnects between ports. Fabric specifies a topology distinct from Point-to-Point and Arbitrated Loop.

informative – Information provided for completeness. Not required.

interoperability – The capability to communicate or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units.

Internet Protocol (IP) – Part of the TCP/IP family of protocols describing software that tracks the Internet address of nodes, routes outgoing messages, and recognizes incoming messages.

N_Port – Node Port. A Fibre Channel term, referring to the link control facility which connects across a link to the F_Port (Fabric Port) at the Fabric (Switch).

NL_Port

node – A point of connection into a network. In Fibre Channel, a collection of one or more N_Ports.

normative – Required for compliance to prescribed norms or standards.

open systems – Everyone would comply with a set of hardware and software standards.

peer-to-peer architecture – A network that contains equivalent nodes with respect to their capability of control or operation.

Point-to-Point – Fibre Channel topology in which communication between two N_Ports occurs without the use of Fabric.

port – Network access point for data entry or exit. In Fibre Channel, a generic reference to an N_Port or F_Port.

protocol – A procedure for adding order to the exchange of data. A specific set of rules, procedures, or conventions relating to format and timing of data transmission between two devices.

simultaneous sampling – Acquiring multiple data within a given time period.

time correlation – The ability to relate two or more asynchronous sources.

time synchronization – The ability to synchronize two or more asynchronous sources.

4 Transport-Level Interoperability Issues

This section addresses the major issues affecting transport interoperability of an instrumentation system network. Node and system designers should be aware of these issues and their effect on a given implementation when beginning a new design or modifying an existing one. Section 0 addresses the document structure and the relationship between sections. As such, each of the following subsections drives changes or deviations to the Fibre Channel standards.

4.1 Fibre Channel Level 0 (FC-0)

The FC-0 level defines the physical portions of Fibre Channel, including the media types, connectors, and the electrical and optical characteristics needed to connect ports. The FC-0 level is designed for maximum flexibility. It allows the use of a large number of technologies to meet the widest range of system requirements.

4.1.1 Cables and Connectors

In a military test vehicle, the environment is typically harsh. Commercial grade cables and connectors can be degraded through vibration, temperature, and altitude to the point of failure. Cables and connectors must be used which can withstand these environments without sacrificing the integrity of the instrumentation system.

4.1.2 Signaling Rate

Fibre Channel supports several signaling rates including quarter speed, half speed, and full speed. There is work within the Fibre Channel committees to allow double and quadruple speed in future revisions of the standard. A fabric may operate with multiple speeds between multiple ports. However, for two nodes to communicate; they must be operating at the same signaling rate.

4.1.3 Signal Quality

In order to ensure interoperability between implementations, it is necessary to specify the signal characteristics of a Fibre Channel transmitter. Though deviations are not expected, it is important any cables and/or connectors chosen as a result of 4.1.1 should meet similar characteristics.

4.2 Fibre Channel Level 1 (FC-1)

FC-1 defines the transmission protocol. Fibre Channel transmits information using an adaptive 8B/10B code to bound the maximum run length of the code, maintain DC-balance, and provide word alignment.

4.3 Fibre Channel Level 2 (FC-2)

The FC-2 level defines the signaling and framing protocol, including frame layout, frame header content, and rules for use. The transported data is transparent to FC-2 and visible to FC-3 and above.

4.3.1 Port Type

Fibre Channel has three basic topologies as stated above. These three topologies require two different port types. Point-to-Point and Fabric topologies use N_Ports while the Arbitrated Loop

topology uses NL_Ports. *[Is an NL_Port a superset of an N_Port? Will an NL_Port work in all three topologies?]*

4.3.2 Login

Fibre Channel nodes must log-in to the fabric or loop (loop initialization) and log-in to a port before data can be exchanged with that port. This process allows the two nodes to establish their operating environment.

4.3.3 Class of Service

Fibre Channel allows several methodologies in which the communication circuit is allocated and retained by the communicating N_Ports and by the level of the delivery integrity required for an application. These methodologies are called classes of service and are denoted by a class number. Currently Fibre Channel has five classes of service as listed below.

Service	Description
Class 1	Dedicated connection
Class 2	Multiplexed connection
Class 3	Datagram
Class 4	Fractional bandwidth
Class 6	Uni-directional dedicated connection

4.4 Fibre Channel Level 3 (FC-3)

FC-3 defines the common services that may be available across multiple ports in a node.

4.5 Fibre Channel Level 4 (FC-4)

FC-4 defines the mapping between lower levels of Fibre Channel and the command sets that use Fibre Channel.

4.5.1 Protocol

There are many upper layer protocols available to place on Fibre Channel. Fibre Channel allows multiple protocols on the network concurrently. However, the protocol must be common to communicating ports. Each protocol is tuned for a particular application. It is up to the designer of each node to utilize the protocol(s) that is (are) best suited for the intended purpose. The system designer must consider the protocols available on each node when designing a system.

5 Fibre Channel Deviations and Clarifications

The following sub-sections describe the mandatory changes to the indicated standards or reports. The majority of the changes are concerned with making optional capabilities mandatory in order to increase the chances of interoperability.

5.1 Fibre Channel Physical and Signaling Interface (FC-PH-x)

FC-PH-x (X3.230, X3.297, X3.303)	
Section	**Change**
2	**Normative References**
	MIL-C-38999 Connectors, Electrical, Circular, General Specification For. *[Gore connector is not strictly per std, Thomas will modify appropriately]*
	MIL-C-17/Quad Cable *[Gore cable is not strictly per std, Thomas will modify appropriately]*
3	**Definitions and Conventions**
3.1.70	NL_Port functionality shall be required
5	**FC-0 Functional Characteristics**
5.1	Addition of Gore cable in the general characteristic section.
5.1	1,063 Mbaud support required
5.7	Media designation for Quad cable will be 'QU' *[We need to pick a designation to identify this quad cable in the FC-0 nomenclature like in Table 3 below.]*
5.8	Update Table 3
7	**Electrical Cable Interface Specification**
	[Thomas updating based on lab tests]
	[Update table 10]
7.4	**Quad Data Link** -- Info will have to be added to include the Gore cable. It should follow the format in the previous/current sections. Content will be based on the results from the test plan and cable mfr.
9	**Electrical Cable Plant Specification**
9	*[Thomas updating based on lab tests]*
9.5	**Quad Cable Plant Specification** (new section) A new section will have to be added to include the Gore cable. It should follow the format in the previous sections. Content will be based on the results from the test plan.
22	**Classes of Service**
22.3	Class 3 – Datagram support is required.

Table in section 5.8:

Part of Table 3, Electrical Media Signal Interface Overview		
100 MB/sec 1,062 5 Gbaud		
100-TV-EL-S Subclause 7.2 0-25m	100-MI-EL-S Subclause 7.2 0-10m	**100-QU-EL-S** **Subclause 7.4** **0-25m**

FC-PH-x (X3.230, X3.297, X3.303)

Section	Change
23	**Login and Service Parameters**
23	Nodes shall support implicit login and optionally support explicit login. *[Here's my thinking...see section 6.3.4]*

5.2 Fibre Channel Arbitrated Loop: FC-AL

FC-AL (X3.272)

Section	Change
11	**Clock Synchronization Service (New Section)**
	Each L_Port shall be capable of storing a time propagation delay value. Whenever the timeserver sends a time value, the L_Port will add its delay value to the time value to update its real-time clock. The delay value format shall be a binary representation of nanoseconds delay. In order to accommodate the maximum delay from a timeserver, a 16 bit data field should be used. *Max delay = 125 nodes × 240ns delay/node + 126 links × 5ns/m × 30m = 48,900ns*

5.3 FC-4 Upper Layer Protocols

[Which protocol should we select? Should we even select one?]

FC-IP, RFC 791?

Section	Change
?	?
	IP support as an upper layer protocol is required

6 Instrumentation System Issues (Informative)

This section is to provide insight to ideas, both good and bad, that may affect a Fibre Channel instrumentation system. As such requirements are not to be construed.

6.1 Architecture

Fibre Channel by itself does not imply the type of architecture an instrumentation system must utilize. There are two basic architectures that can be employed in the design of the system. The nodes may or may not support both architectures. In the traditional system, a controller or master is used to command the nodes and receive the responses. The controller is programmed with the knowledge of the overall format and directs each node to acquire data and respond (reference Figure 1). The controller typically becomes the aggregator of the data as it formats the output(s) for recording, transmitting, or processing. This keeps the nodes simple. Traffic on the bus is very orderly based on what the controller requests. This is known as a command-response architecture. Multiple formats can be stored in the controller and changed via a cockpit switch or sophisticated uplink. Controllers can vary from small, inexpensive units that are inflexible to large expensive units that can do everything.
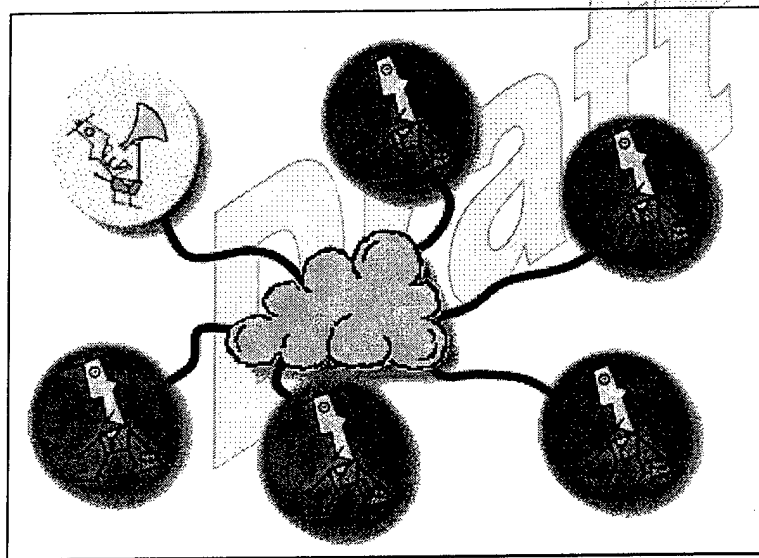

Figure 1, Controller Based Architecture

Another architecture available to the instrumentation network is the peer-to-peer architecture. Each node is programmed with its own schedule. Individually the nodes determine when to acquire the data, what format to packet the data into, and to whom to send it (reference Figure 2). One of the advantages of an autonomous system is the ease to add new nodes. Additional nodes just need to be physically connected to the bus and programmed. The other nodes are not affected (assuming plenty of bandwidth on the bus and the data sinks). One node could still receive all the data and format it into the proper outputs for recording and transmitting similar to the command response architecture.
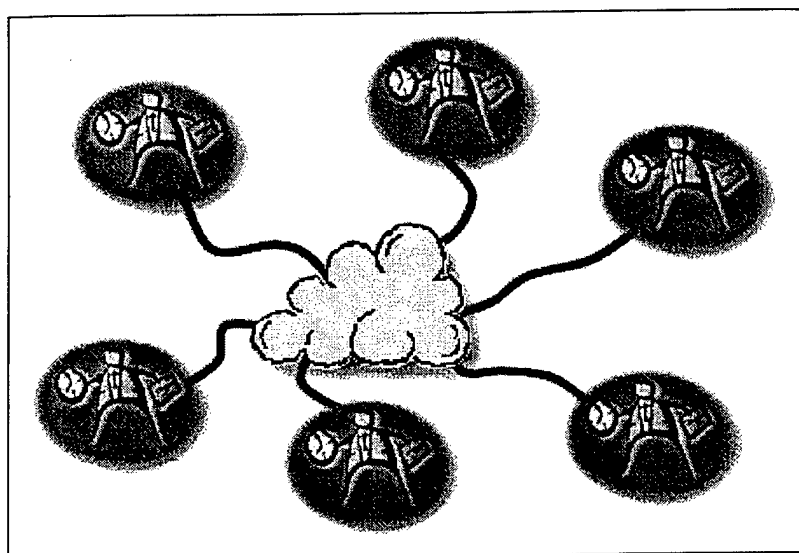
Figure 2, Peer-to-Peer Architecture

6.2 Open System

In an open system, the specifications are generally in the public domain. Of particular importance is the specifications should be in wide use as well. This allows ready access not only to the specifications, but also to the chipsets, OEM boards, drivers, and test equipment.

6.3 Topology

Fibre Channel defines three major topologies – point-to-point, fabric, and arbitrated loop. The point-to-point topology is the simplest. It connects two ports with a bi-directional link (reference Figure 3).
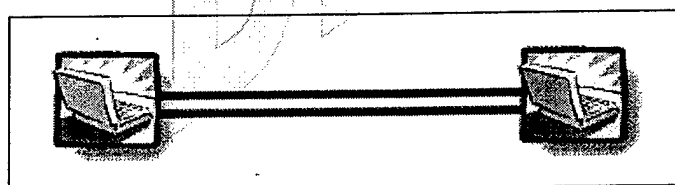

Figure 3, Point-to-Point Topology

In the fabric topology, each node is connected to a switch. Depending on the capabilities of the switch, any node may connect to any other node (reference Figure 4). When denoting fabric topologies, the fabric is shown as a cloud. This represents the fabric notion without showing any physical connections. One of the drawbacks of fabric, is the requirement for one or more fabric switches that physically take the place of the network cloud. These are not necessarily cheap – especially for a test environment. However, because of the connectivity, adding additional nodes increases the total bandwidth available to the system. In reality, this is only true if there is a broad distribution of network traffic. If all nodes are trying to talk through one link to the recorder, then more nodes will only make it worse.
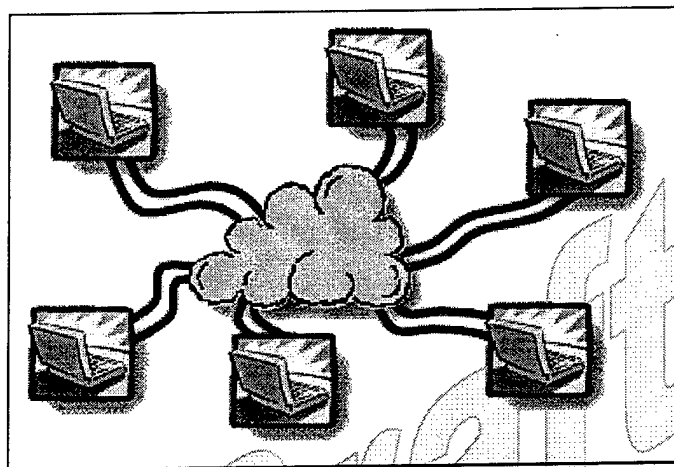

Figure 4, Fabric Topology

The arbitrated loop topology is a simple concatenation from the transmitter of one node to the receiver of the next. This progresses through all nodes until the last one is connected to form a loop (reference Figure 5). Simplicity is one of the advantages of a loop. There is no additional network hardware required for connectivity. To add more nodes, the loop is broken with the additional nodes being inserted between the break. One of the drawbacks of a loop is the constant bandwidth. Regardless of the number of nodes, they all share the same bandwidth.
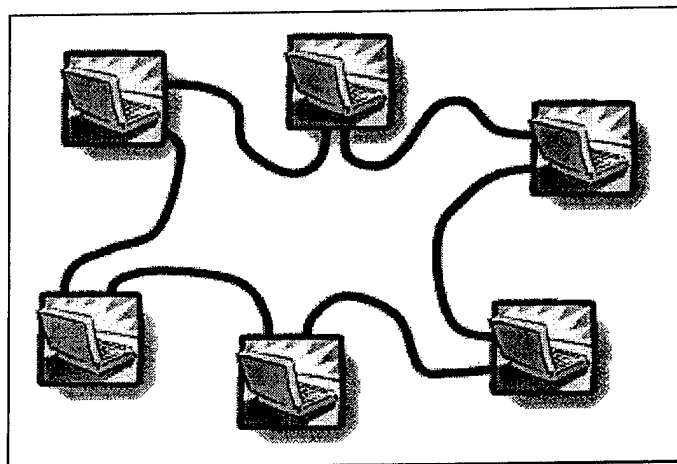

Figure 5, Arbitrated Loop Topology

The last type of topology available is the hybrid topology. The hybrid topology simply replaces on of the fabric nodes with a loop. Conversely, it replaces a loop node with a fabric (reference Figure 6). This is one instance of a hybrid topology, of which there are many variations. This topology has the pros and cons of both.
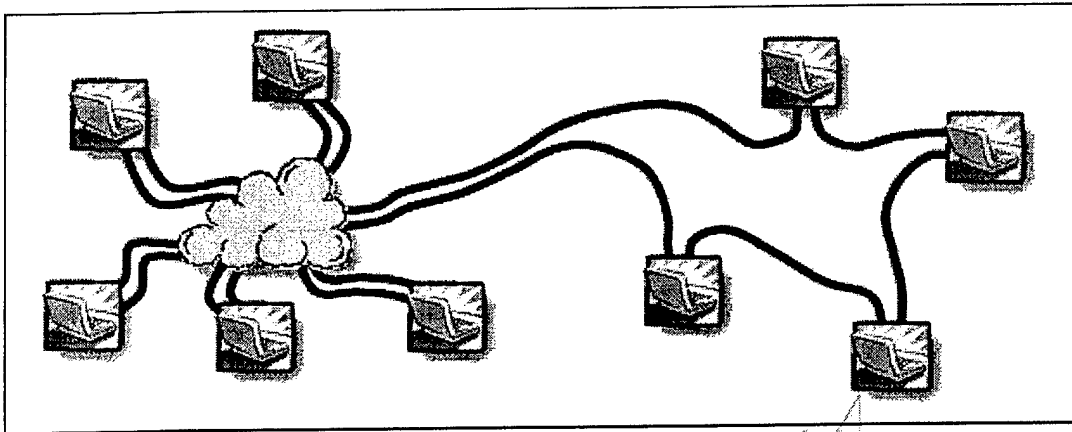

Figure 6, Hybrid Topology

6.4 Fault Tolerance

In systems most instrumentation engineers are familiar with, a single point failure rarely brought the system to its knees. With traditional instrumentation systems, a faulty connection on a data acquisition unit simply meant no data would come from that unit. The rest of the system would continue to operate. The same is true for Mil-Std-1553 systems. With switched fabric systems, the switches become a single point failure. One single-point-failure mode does not seem like a big deal. Current systems have a single point failure in the system controller. When we consider arbitrated loop systems – each node on the loop is a single-point-failure source. There are several ways to make these systems more fault tolerant such as: port bypass circuitry, hubs, and built in redundancy.

6.4.1 Port Bypass

One way to add tolerance to a loop topology is to add port bypass circuitry to each node. If something happens to the node (loss of power or other problem) the bypass kicks in and allows the loop to continue to operate. The node designer must add this circuitry to the unit prior to production. The port bypass circuit will not help a faulty connection to the port itself.

6.4.2 Hub

A hub allows a logical loop topology to be physically connected in a star fashion. The hub acts as a security guard monitoring the health of each of the ports. When it detects a failure on one of the ports, it bypasses the faulty port within the hub (reference Figure 7). In this way, a port and its associated wiring can be completely removed and not affect the system. This works well, however, many of the drawbacks of the switched fabric topology have been reintroduced. For example, the added expense (hardware and time) of routing the links back to a central location as well as the cost and maintenance of the hub.
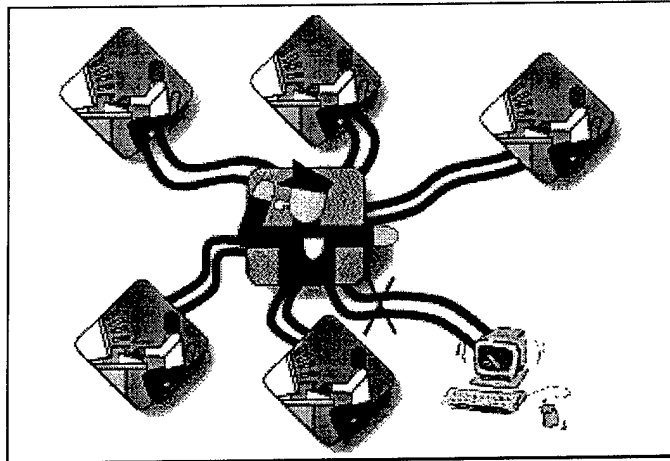
Figure 7, Arbitrated Loop with Hub

6.4.3 Redundancy

Another solution, which must be designed into the port, is a redundant bus. For fabrics, it means multiple ports on each node. Each port is connected to the fabric and receives its own port address. The node is responsible for merging data from among its ports. To the rest of the fabric, it looks like there are more ports. For the data rates expected in initial instrumentation systems, wholesale redundant busses for fabrics do not seem to gain much. However, the concept of multiple ports for high bandwidth data sinks like recorders has merit. For loops, an additional connection between nodes in the opposite direction is installed. This creates a counter-rotating ring. If there is a connection failure, data can still traverse the ring.

Avionics busses used to control the test vehicles have typically had redundancy built into the system. Given the bit error rates of operational systems in the past and the criticality of a failure, it was essential. Redundancy in instrumentation systems has been the exception rather than the rule. A Fibre Channel system built to the ANSI standards has a lower bit error rate than anything used previously. The system designer must decide if redundancy is required for a given implementation. Possible choices include counter rotating rings and dual ported nodes.

6.4.4 Addressing

When a port logs into the fabric, or when the loop is initialized, the port addresses are assigned. Fibre Channel allows a port to request a previously assigned address. It suggests [?] the port requests an address on a cold start. The big concern here would be for systems where new nodes may be coming online at random or under some other control. Since the test vehicle is a private system where the instrumentation engineer has the knowledge of what nodes are in the system, static addresses should not be a problem. The ability to preset an address would be preferable for many reasons – not the least of which would be trouble-shooting.

6.5 Timing

[We need to do some work here. Given the tolerance of the clock, system delays, etc., what is the best we can hope for empirically? How close to that do we think we can get?

Network Time Protocol (NTP) ???

18

[Loop Timing
Signaling rate of 1 062 Mbaud ±100ppm = 962 to 1 162 Mbaud
Clock rate of 1.039 to 0.860 ns = ±0.09 ns
Clock uncertainty from 126 nodes = ±0.09ns * 126 = ±11.3 ns
If propagation delay through node cannot be determined precisely, but is speced ±10 ns,
Additional uncertainty = ±10ns * 126 = ±1 260 ns = ±1.26 us
Even if the node is speced to ±1ns, it would still add ±126 ns uncertainty to the full loop, beyond
our original 100ns requirement (±100??)]

Timing is one of the most critical issues facing instrumentation networks. There are three major timing issues: time correlation of data, simultaneous sampling, and the reconstruction of data sources. Synchronizing the nodes to a common time source, if done accurately enough, could solve all three issues. Synchronization issues differ upon the topology selected.

6.5.1 Data Correlation

Time correlation of data requires knowledge of when a sample occurred in relation to other samples. If both samples occur within the same node, the issue is trivial. When they occur across different nodes, the time relationship between the nodes needs to be known.

6.5.2 Simultaneous Sampling

In some instances, knowing when different samples occurred is not good enough. The samples need to be acquired at the same moment in time in order for data processing issues to be reduced to a manageable level.

6.5.3 Data Source Reconstruction

Data source reconstruction is similar to data correlation, but a bit more specific. For some data sources, like Mil-Std-1553 data busses, the user wants to recreate the bus exactly for use with simulators or trouble-shooting equipment. In a packet-based environment, each packet will be stamped with the time of arrival. The fidelity of the time stamps will vary with the requirement for reconstruction.

6.6 Interoperability

Section 4 discussed what the interoperability issues were. Section 5 was the interoperability implementation requirements. This section will explain some of the rationale of why certain values were selected.

6.6.1 Cables and Connectors

The Fibre Channel standards were written with benign environments in mind. Because of space constraints within test vehicles, signal wires are sometimes tied in the same bundles as power lines and coaxial cabling. The proximity of radars, avionics, and power distribution units creates an environment most cable/connector sets cannot tolerate. Because of this harsh environment, the physical component was expected to deviate from the standard. Changing the physical level should not affect the ability to leverage the commercial industry.

6.6.2 Port Type

Since this is an interoperability document, it was decided not to arbitrarily choose a topology. There are pros and cons to both that the system designer should decide what is best for their application. The selection of the NL_Port allows any of the topologies to be used.

6.6.3 Signaling Rate

For two nodes to communicate, they must operate at the same signaling rate. Full speed is by far the most prevalent and the one most vendors will design into their units. This does not preclude the use of other rates like quarter speed or faster rates in the future. This will ensure all units have a common rate with which to communicate.

6.6.4 Login

[Will require some more discussion/research...
The requirement is interoperability. Since the instrumentation network is a private network –
especially in the beginning, the system designer knows what nodes he wants to put on the
network and how they need to operate. The login parameters can be predefined in EEPROM
or something. Explicit login seems like an "auto-negotiate" routine which adds a level of
complication. I was told that nodes by two manufacturers would not explicitly login. If it
wasn't for implicit logins, they wouldn't have gotten the two nodes to communicate. I'll check
for more details. Probably the greater concern is to ensure the variety of login parameters
allow interoperability. For example, do we need to define default common service parameters
for FLOGI and/or PLOGI?]

6.6.5 Class of Service

Much the same as signaling rate, Fibre Channel allows several choices. However, class three seems the most prevalent. Again, this does not preclude the use of other classes.

6.6.6 Protocol

[This needs some work too. I'm leaning towards IP]
Since NexGenBus did not study the upper layer protocols (ULP), selecting the most capable protocol is out of the question. The most prevalent ULP seems to be the only choice. The ULP used frequently on Fibre Channel is the SCSI protocol. This protocol has been used for years for read/write commands between a host (PC) and a target (tape drive). Because of Fibre Channel's robust architecture and low latency to send and receive SCSI commands, the use of SCSI in a Storage Area Network (SAN) has become almost universal. Recently the use of TCP/IP drivers on Fibre Channel has become prevalent. The use of TCP provides the ability to interoperate with a many different devices. The penalty is that TCP use a connection oriented protocol in which acknowledgments are received for each packet. This creates additional traffic on the network, which reduces throughput and increases latency. An alternative to TCP is UDP, which uses the same size packet, etc. but does not acknowledge packets received. This increases throughput and decreases latency. Although not strictly a upper layer protocol, the Internet Protocol (IP) is the must pervasive protocol in use today. It provides a connectionless method of connecting but has a rich set of tools developed for the Internet. The IP Protocol is used with either TCP or UDP. Many vendors are providing IP drivers along with their SCSI drivers.